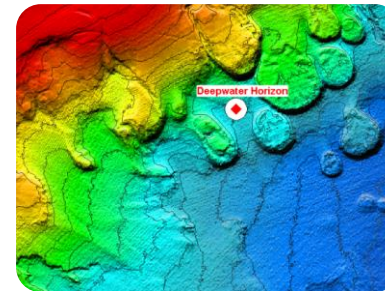
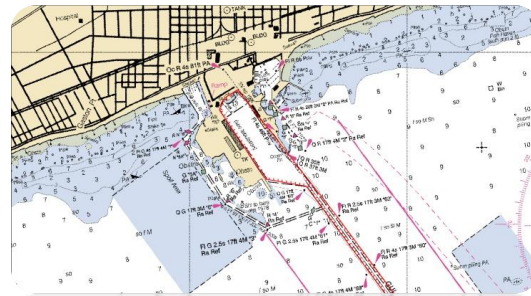


Surface Current Data for Precision Navigation Applications

Dr. Neil D. Weston
Technical Director
Office of Coast Survey, NOAA



Office of Coast Survey
National Oceanic and Atmospheric Administration

Operational Forecast Systems - OFS

- NOAA operational nowcast and forecast models
- Run 24 hours per day; output every 6 hours
- Support NOAA mission goals and priorities
- Operational Forecast System - Data



Water Level



Wind



Water Temperature



Salinity



Currents

- Operational Forecast System - Components
 - Hydrodynamic model predictions
 - Product dissemination
 - Quality control monitoring



Operational Forecast System – Lower Chesapeake Bay

Model Inputs

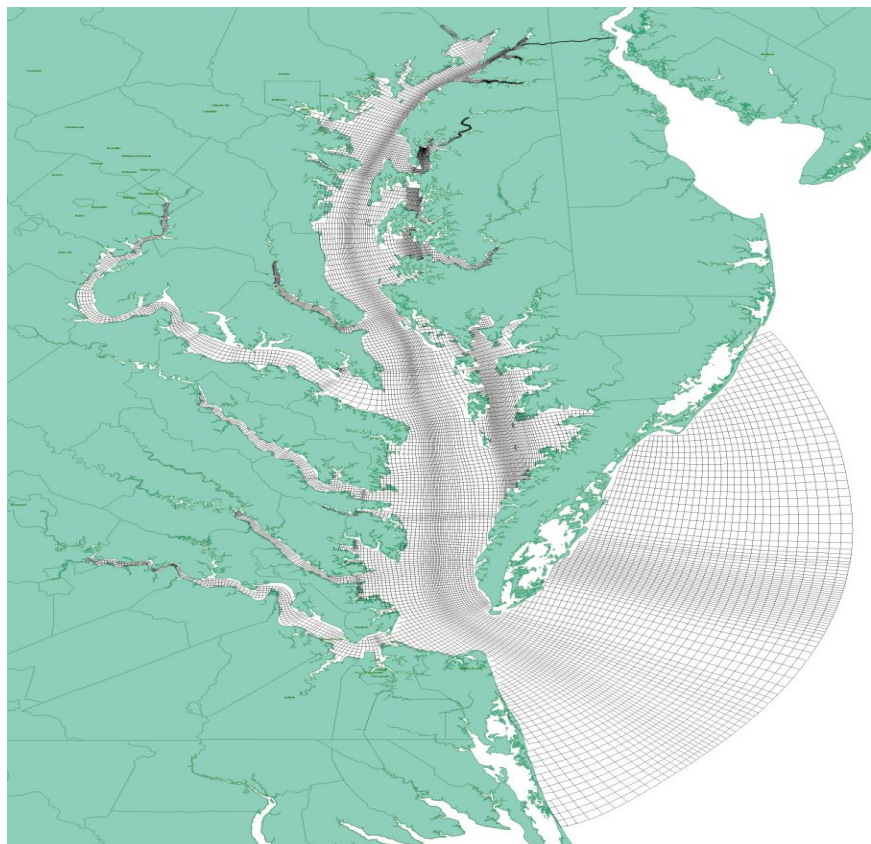
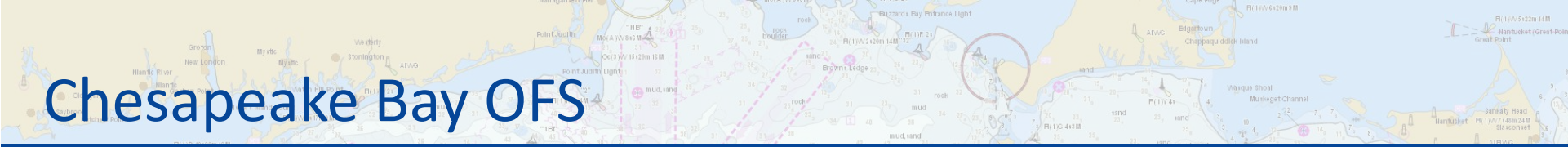
Winds
Water Levels
Currents

Model Outputs

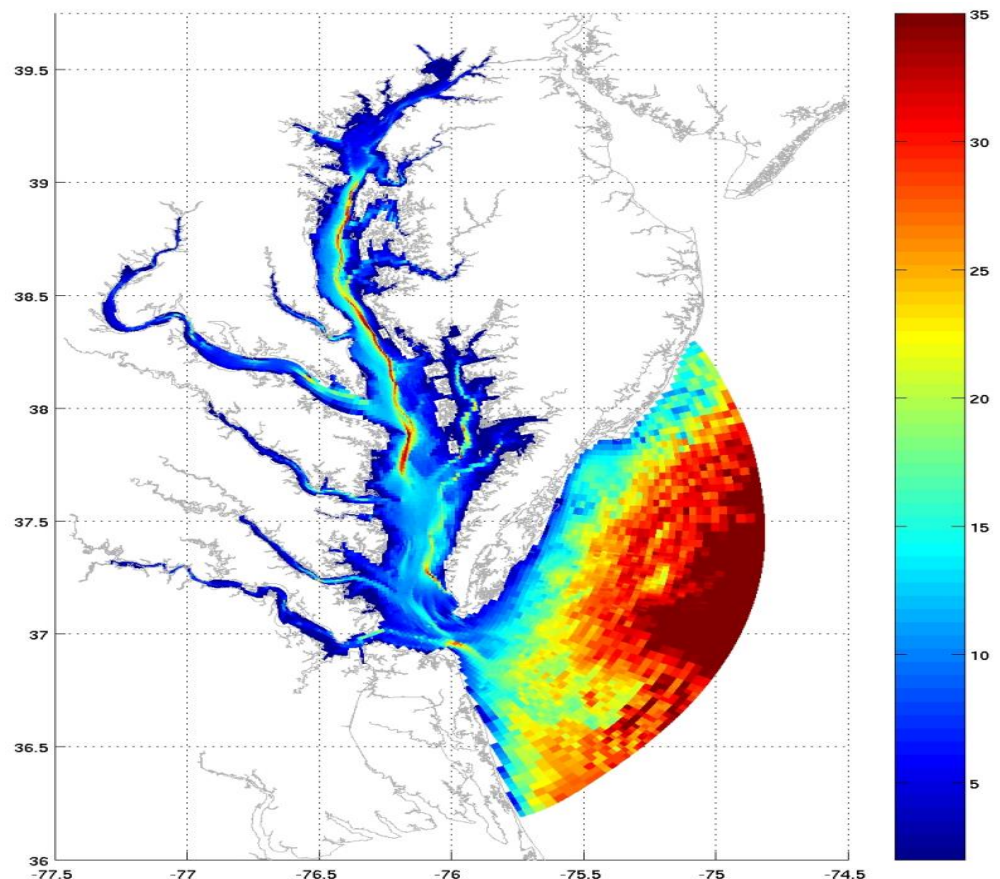
Water Levels
Currents
Water Temperature
Water Salinity



Office of Coast Survey
National Oceanic and Atmospheric Administration



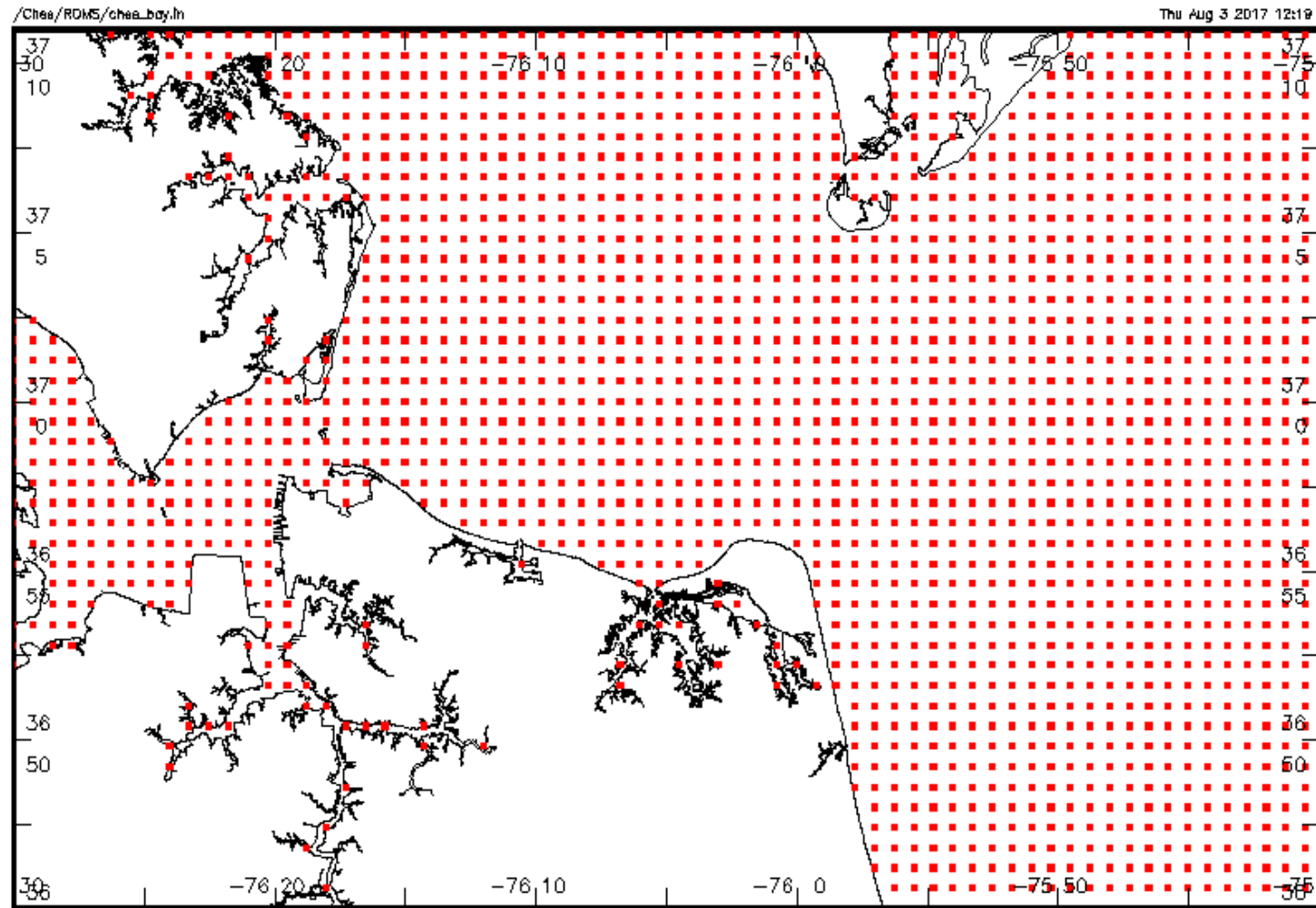
Irregular node spacing – 78,480 pts



Water depth - meters



Chesapeake Bay – Regular Node Spacing



$dx = 0.010 \text{ deg}$ $dy = 0.010 \text{ deg}$



Office of Coast Survey
National Oceanic and Atmospheric Administration



Surface Currents - Operationalize S-111 Data

Description

- Develop a service to disseminate OFS surface current data in the IHO's S-111 format
- For use in Electronic Navigation Systems (ENC)
- S-111 data is designed for interoperability
- IHO product specifications based on S-100 Framework
- S-111 Surface Currents Product Specification adopted by IHO on February 13, 2019



Surface Currents S-111 Metadata

Variable	Value
IHO Specifications	S-100 Edition 4.0.0 S-111 Edition 1.0.0
Format	Hierarchical Data Format 5 (HDF5)
Operational Forecast System (OFS) Parameter(s)	Surface Currents
Coordinate System	WGS 84
Frequency	4 times daily cycle (0, 6, 12, 18 UTC)
Time Resolution, Duration	Hourly out to 48 hours
Time Zone	UTC
Resolution	~500 m (regular grid)
Depth	4.5 m below surface
Data Coverage	Chesapeake Bay, VA/MD/DC (CBOFS); Delaware Bay, DE/NJ (DBOFS) (as of Dec '18)
Hydrodynamic Model	Regional Ocean Modeling System (ROMS)



Lower Chesapeake Bay

ENC Band: 4

Format: S-111 w/ HDF5 encoding

Grid Resolution: 0.01 deg

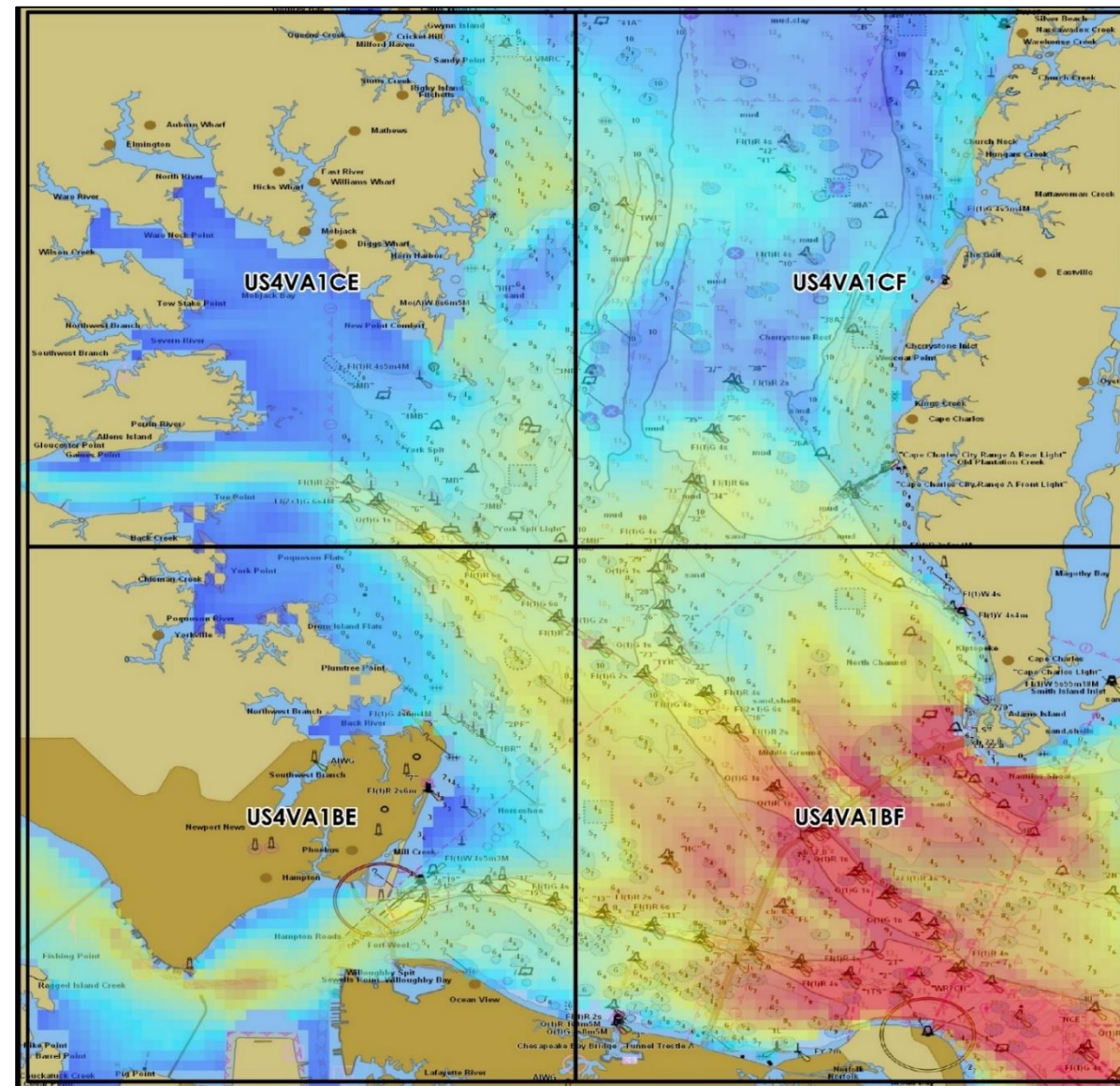
Parameter: Surface currents

Coordinate System: WGS 84

Dataset: 72 hours, 1 hr intervals

Time Zone: UTC

Date: 19:00 December 3rd, 2018



Office of Coast Survey
National Oceanic and Atmospheric Administration

Lower Chesapeake Bay

ENC Band: 4

Format: S-111 w/ HDF5 encoding

Grid Resolution: 0.01 deg

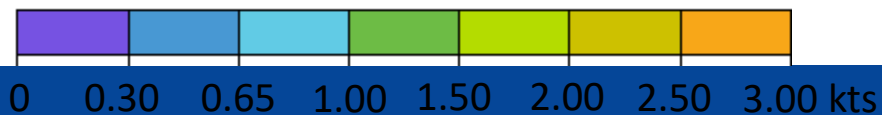
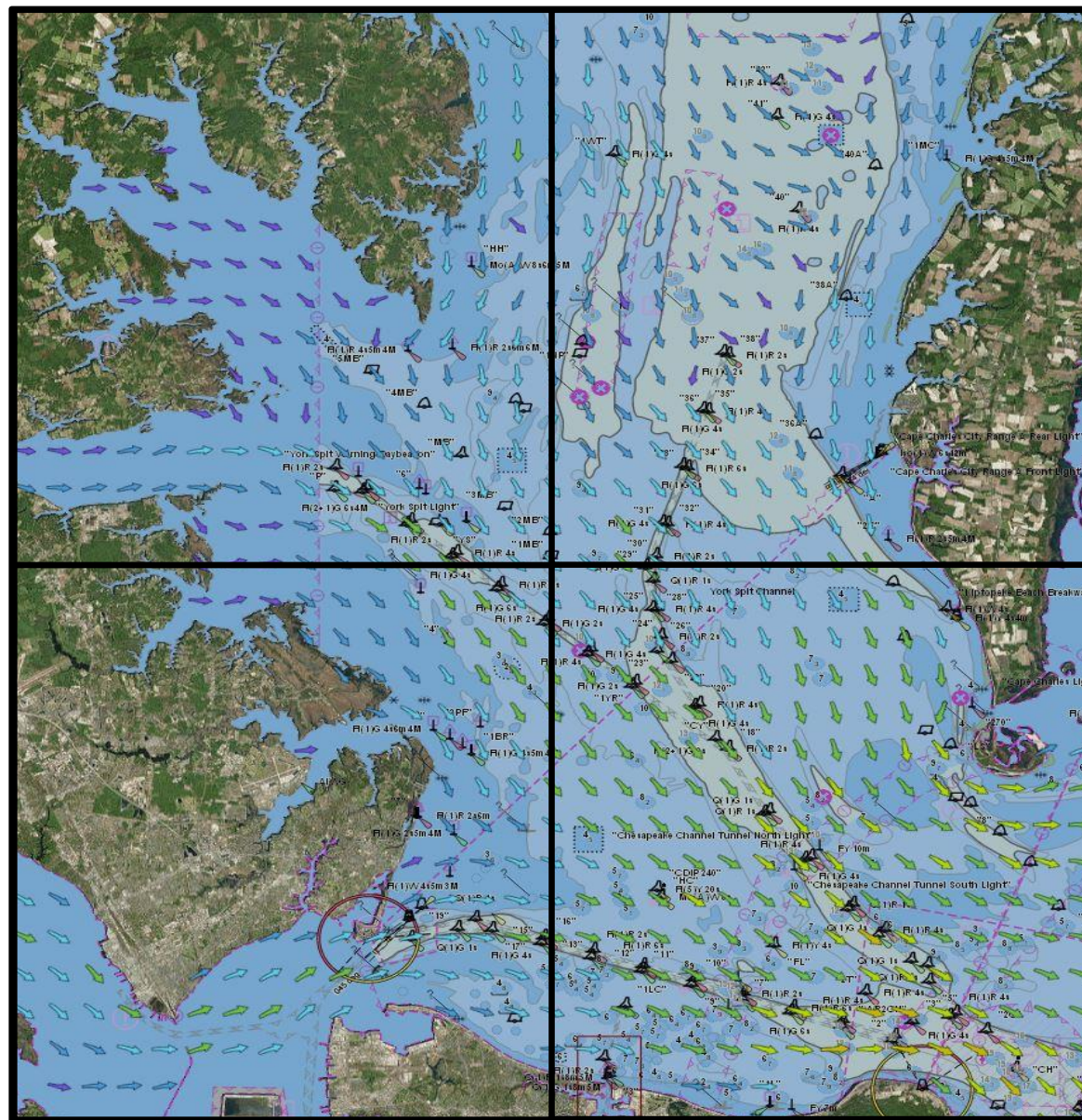
Parameter: Surface currents

Coordinate System: WGS 84

Dataset: 72 hours, 1 hr intervals

Time Zone: UTC

Date: 19:00 December 3rd, 2018



Office of Coast Survey
National Oceanic and Atmospheric Administration

NOAA Electronic Navigation Charts (ENC)

ENC Band: 4

OFS: Chesapeake Bay, Delaware Bay, New York Harbor

Format: S-111 w/ HDF5 encoding

Grid Resolution: 0.01 deg

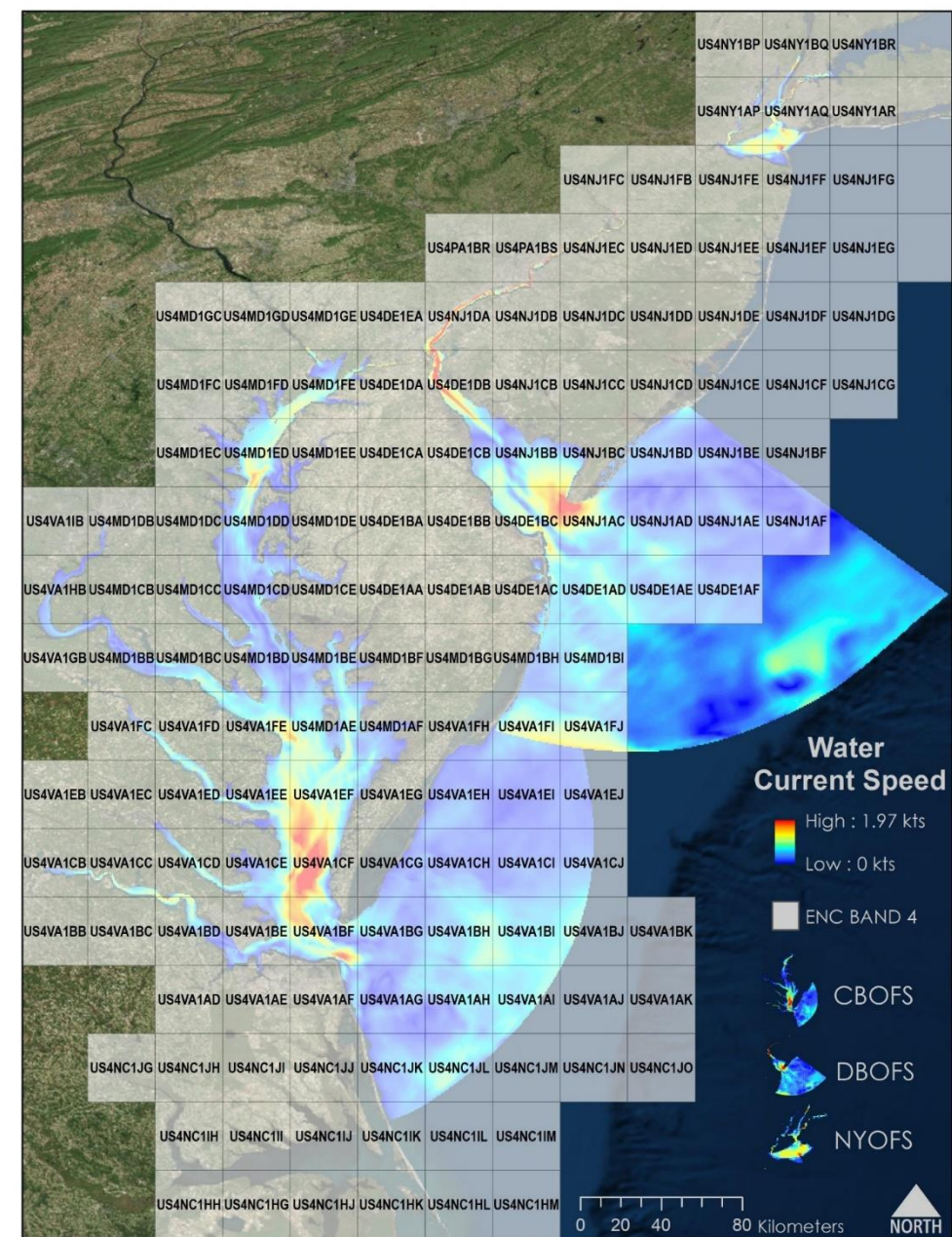
Parameter: Surface currents

Coordinate System: WGS 84

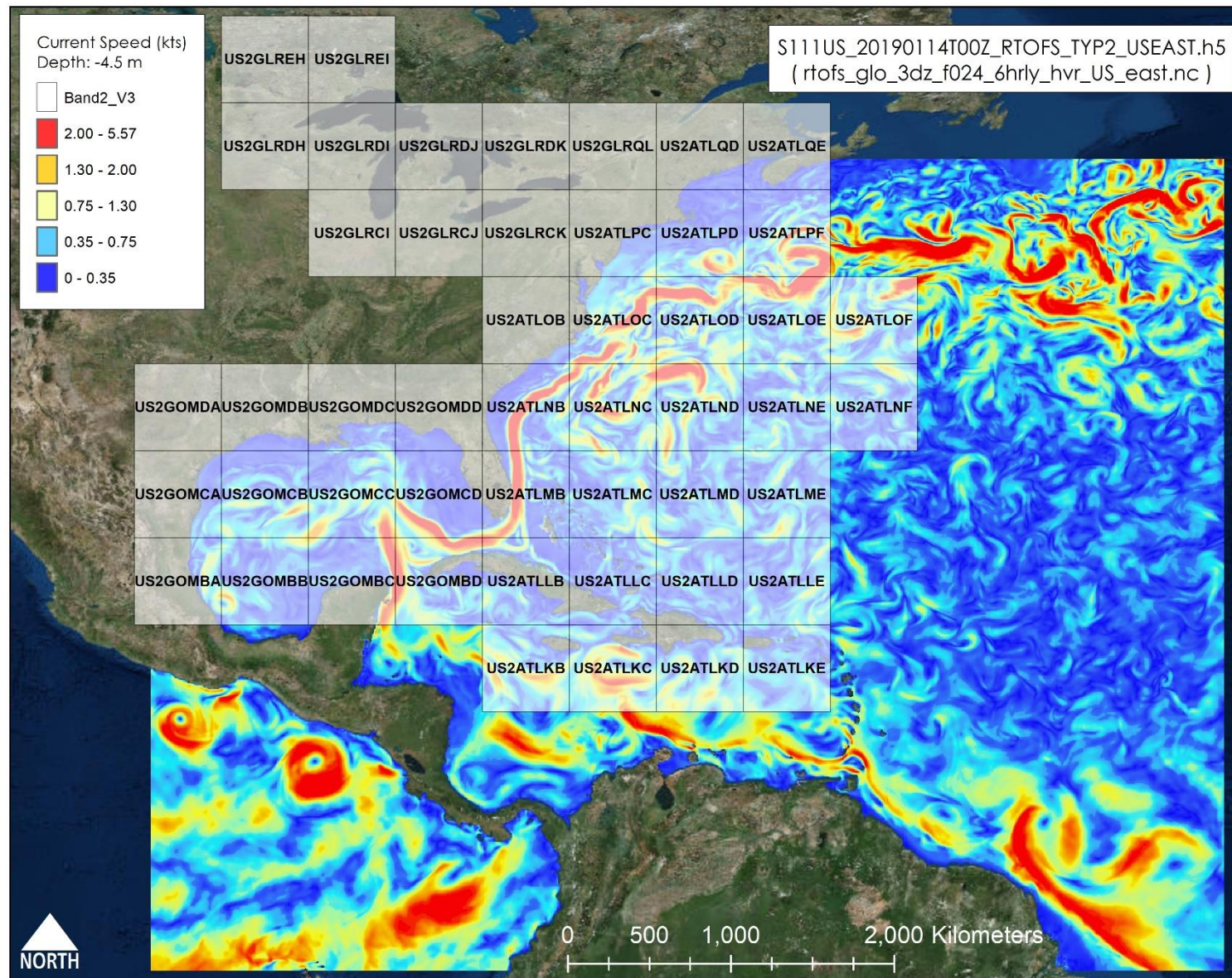
Dataset: 72 hours, 1 hr intervals

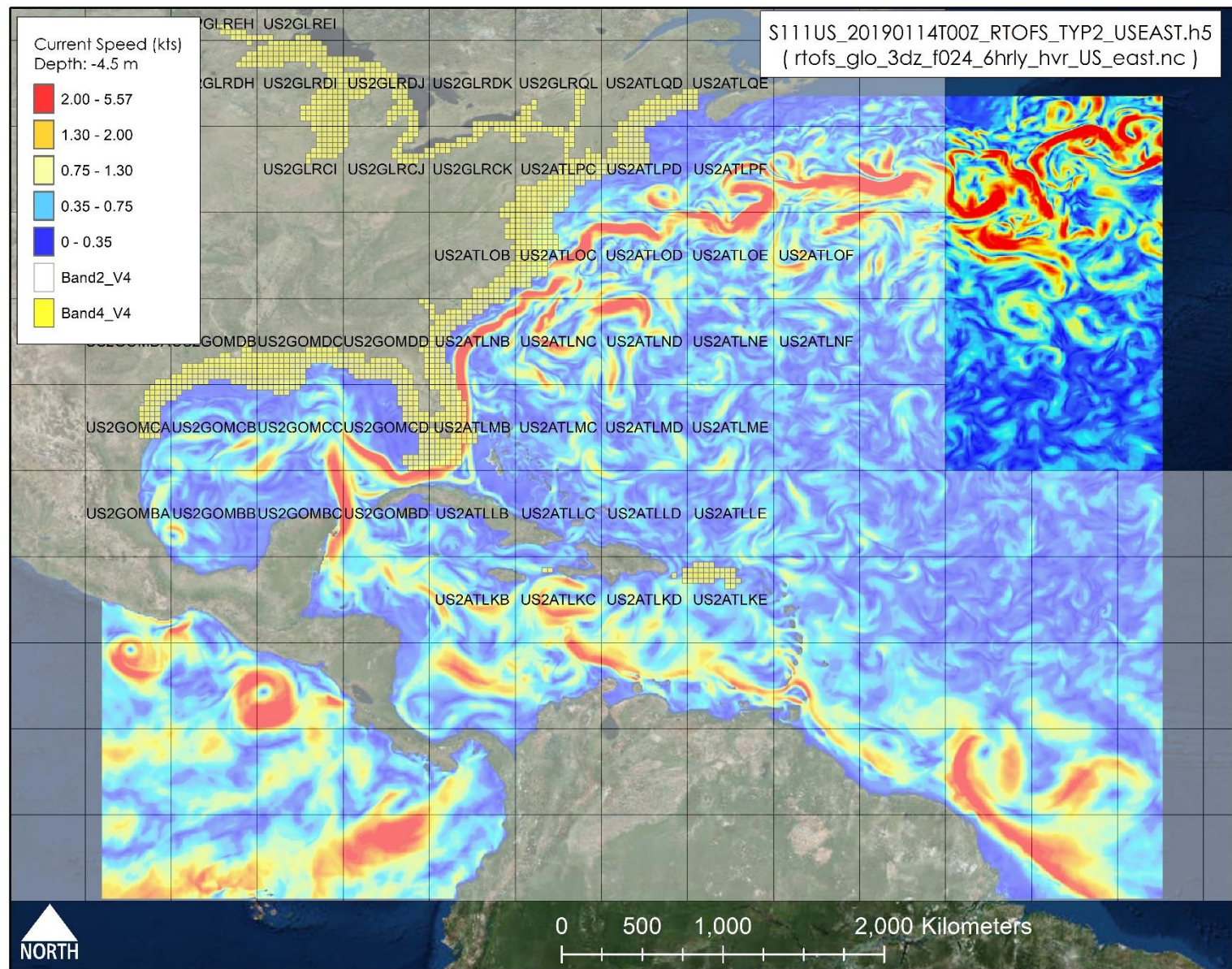
Time Zone: UTC

Date: 19:00 December 3rd, 2018

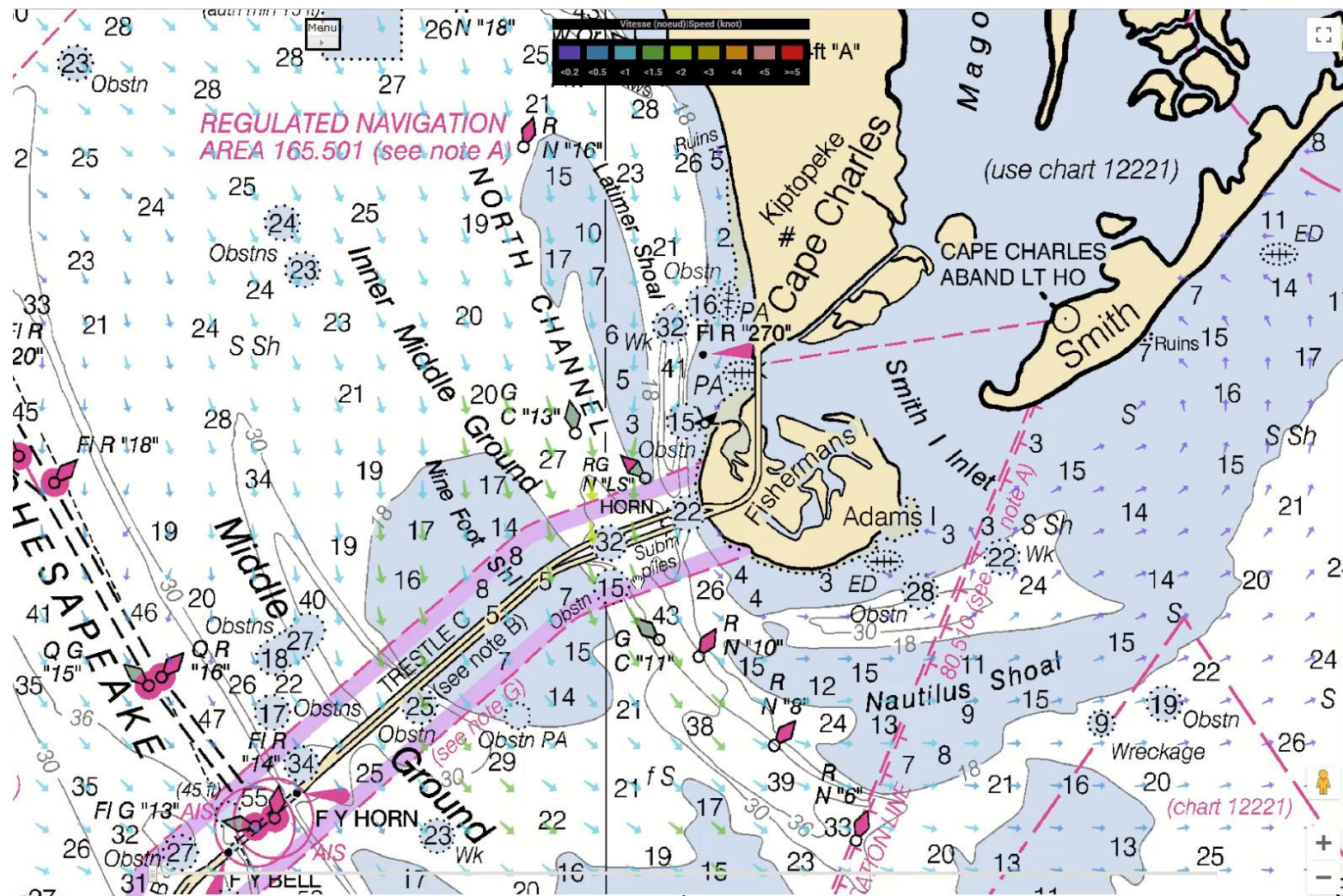


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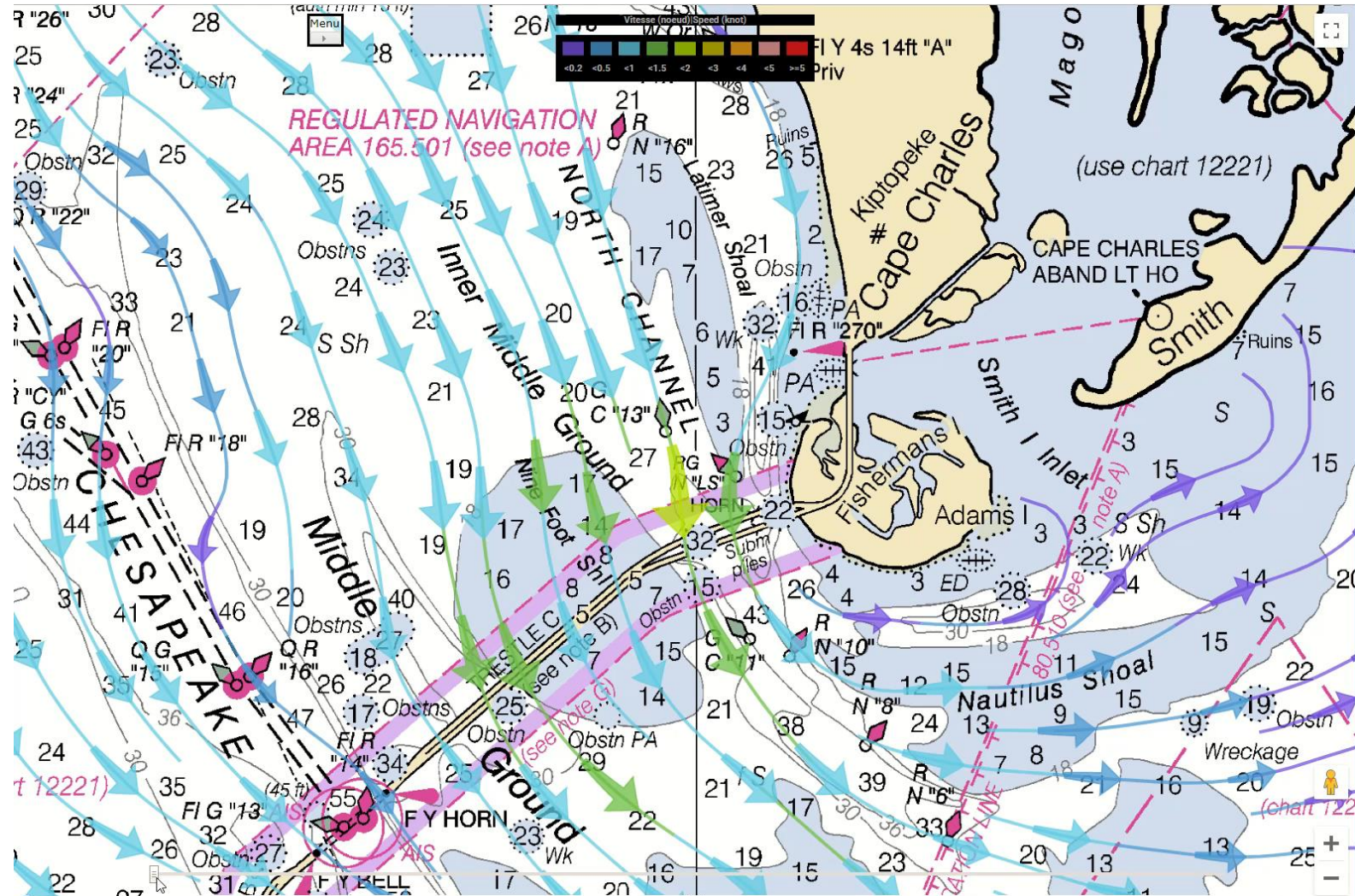




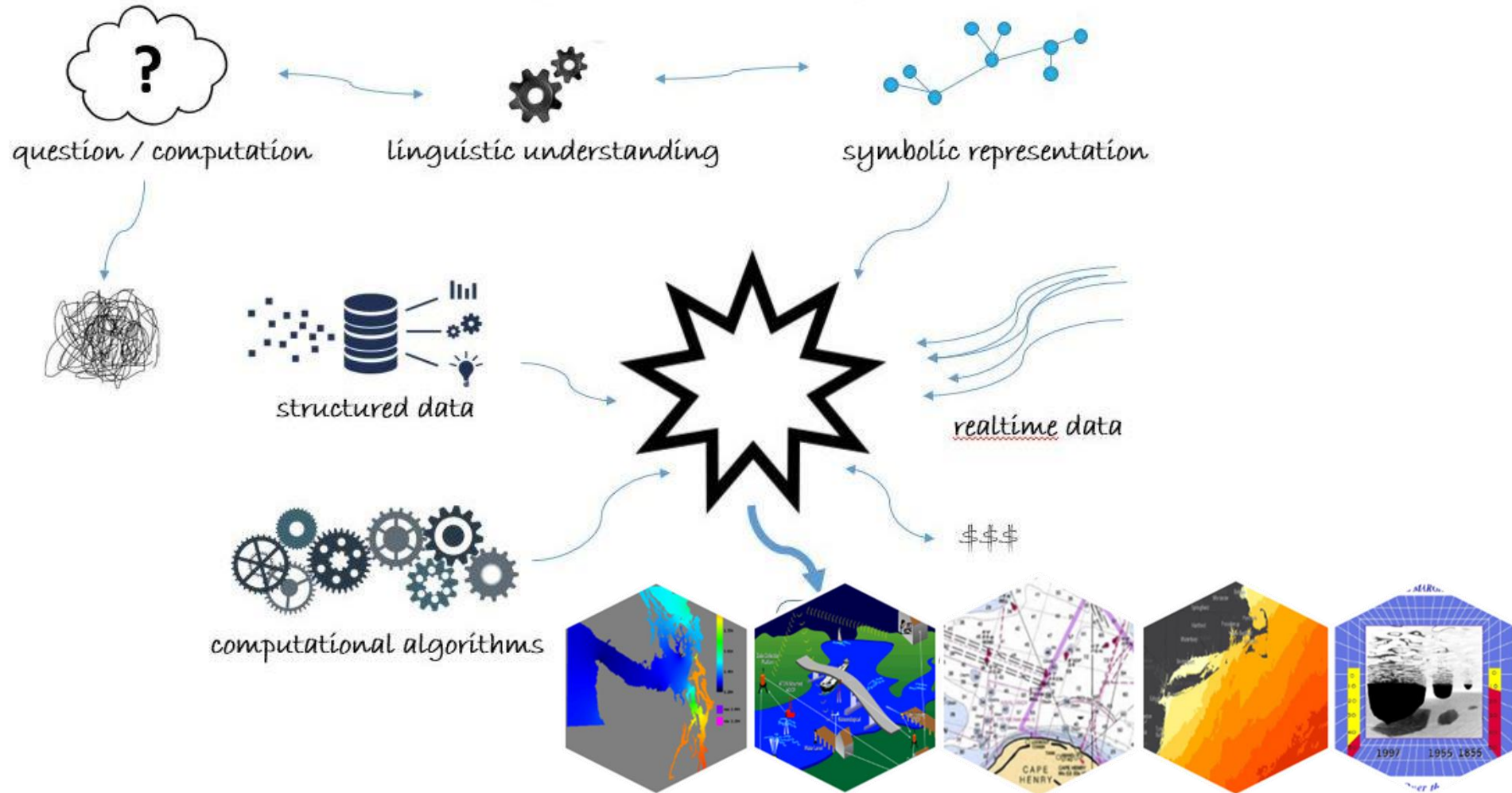
S-111 Grid Portrayal Example

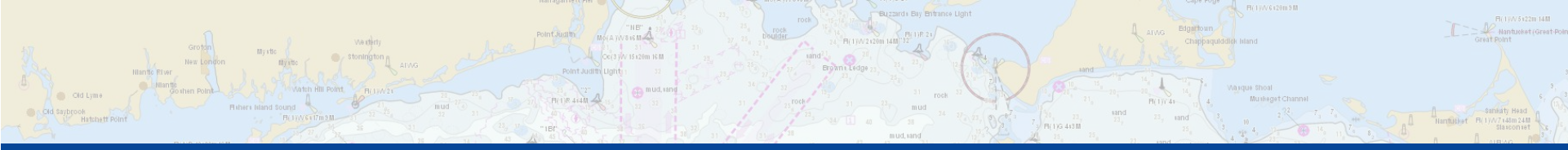


CCOM/JHC Proposed Streamline Portrayal



Precision Navigation





National Oceanic & Atmospheric Administration: www.noaa.gov

Office of Coast Survey: nauticalcharts.noaa.gov

International Hydrographic Organization: iho.int

U.S. Committee on Maritime Transportation System: www.cmts.gov

Thank You

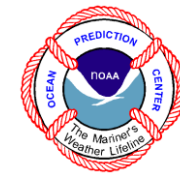
Neil Weston - Office of Coast Survey, NOAA

neil.d.weston@noaa.gov

240-847-8250

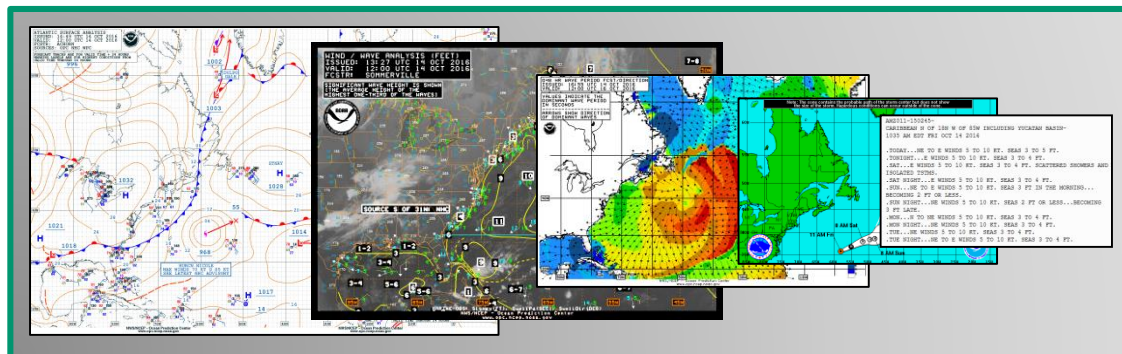


Office of Coast Survey
National Oceanic and Atmospheric Administration



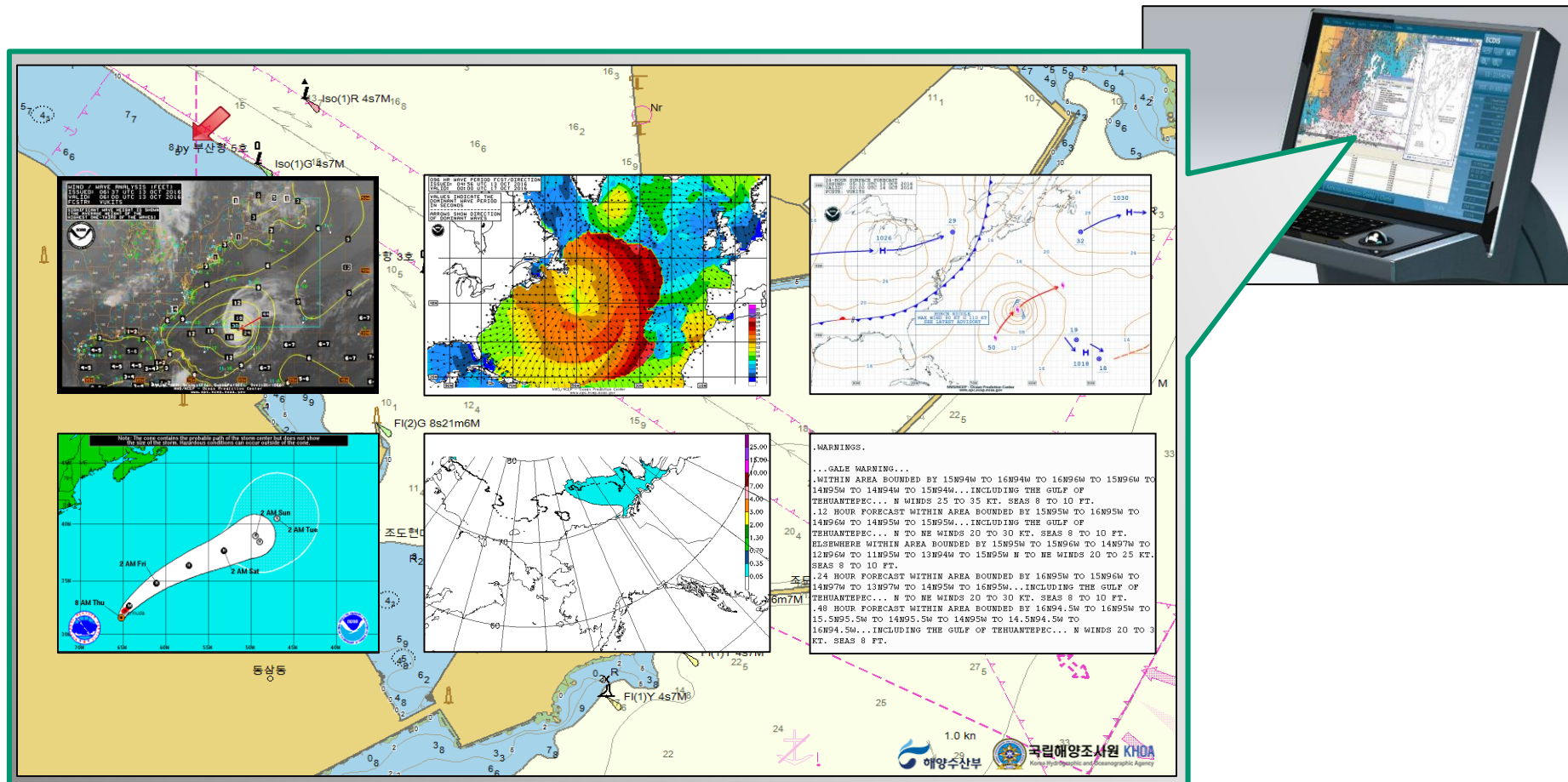
S-41X: Marine Weather Overlays

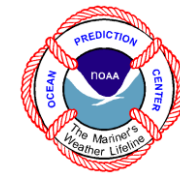
ENS Hillary Fort, NOAA Commissioned Corps
Technical Operations Coordinator
Joseph Sienkiewicz, Chief, Oceans Applications Branch
Robert Daniels, Oceanographer/Developer
National Weather Service - Ocean Prediction Center
5830 University Research Court, W/NP42, Room 4637
O: (301) 683-1555



S-41X Weather Overlay Goal

Develop a navigation safety S-100 based product specification for weather information for use in Electronic Chart Systems (ECS) including Electronic Chart Display and Information Systems (ECDIS).





Background & Context

May of 2012, the 4th session

- World Meteorological Organization (WMO)
 - Intergovernmental Oceanographic Commission (IOC)
 - Technical Commission for Oceanography and Marine Meteorology (JCOMM)



WORLD
METEOROLOGICAL
ORGANIZATION

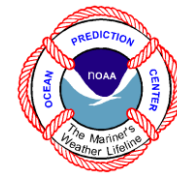


Established the need for developing a **marine weather overlay** for electronic charting systems, including Electronic Chart Display and Information Systems (ECDIS).



Background & Context

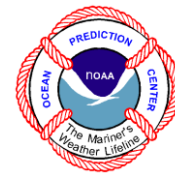
International Development Effort



JCOMM officially designated US/NOAA as project lead in 2012.



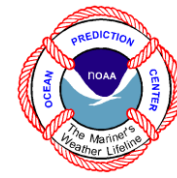
Paraphrased S-41X Weather Overlay Requirements



- (1) Allow for:
 - Atmospheric systems
 - Messages (warnings, watches, advisories, synopsis, forecast statements, etc) – emphasis on polygonal warnings
 - Sea-surface conditions
 - Marine and coastal weather and wave observations
 - Vector (weather objects/polygons) and gridded formats
 - As much as practical, compliant with the Joint IMO/IHO/WMO Manual on Maritime Safety Information (MSI).
- (2) Warning requirements, visuals and terminology shall, as much as practical, match the standardization outlined in WMO 558.
- (3) Where possible, these product specifications should harmonize with other S-100 based product specifications.



S-41X Weather Overlays: Requirements



Main

- Specifies what is needed to build a complete product
- Feature Types
- Geometry
- Data formats and file size
- Metadata

Feature Catalogue

- Features
- Attributes
- Enumerants
- Bindings
- Point, Curve or Surface

Portrayal Catalogue

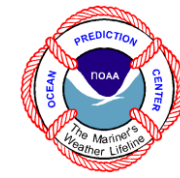
- Symbols, Line Styles and Area Fills
- Rule for how the feature attribute combination must be portrayed

Data Classification and Encoding Guide

- Contains the guidance for how the data should be encoded by the data producer
- Useful as a template for building the feature catalogue

Exchange Format

- Data format that is used for data exchange
- ISO 8211 - normally used for ECDIS



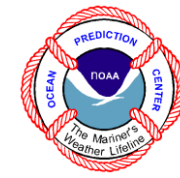
Vision and Desired Outcome

S-41X Weather Overlay Product Specifications



S-412	S-413	S-414
Wave and Weather Hazards	Wave and Weather Conditions	Wave and Weather Observations
Polygons	Features (e.g. fronts) Gridded Data	Point Based Data

*Separation of product specifications
approved as of May 17, 2019*



S-412 Weather and Wave Hazards

Weather Messages

- Weather message
- Tropical cyclone messages
- Thunderstorm message
- High wind message
- Freezing spray message
- Reduced visibility message
- Large seas message

Weather Systems

- Tropical cyclone
- Thunderstorm

Data Format:

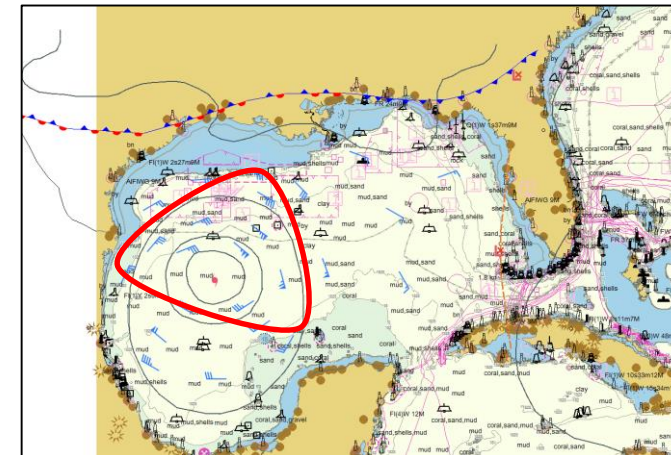
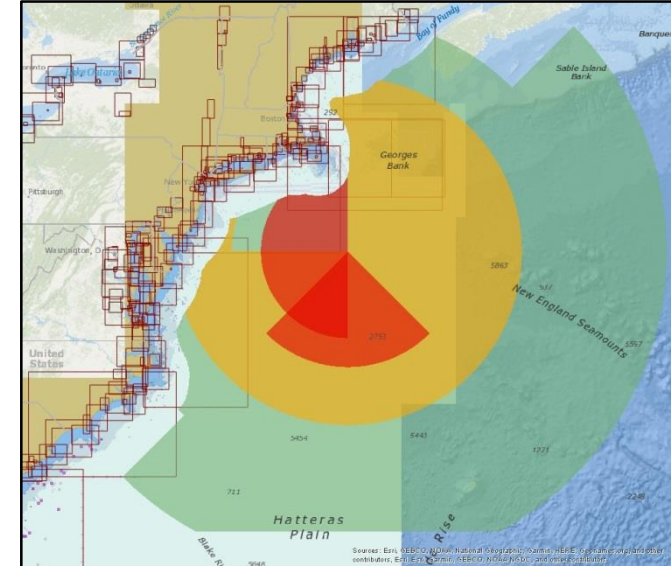
- Geographic Markup Language (GML) 3.2.1

Technical Development Requirements:

- GML Schema file
- Catalogue files
- Forecast Data → S-100 GML Polygon converter

Notes

- Message features include watch, warnings, advisories, statements, outlooks, and synopsis distinctions

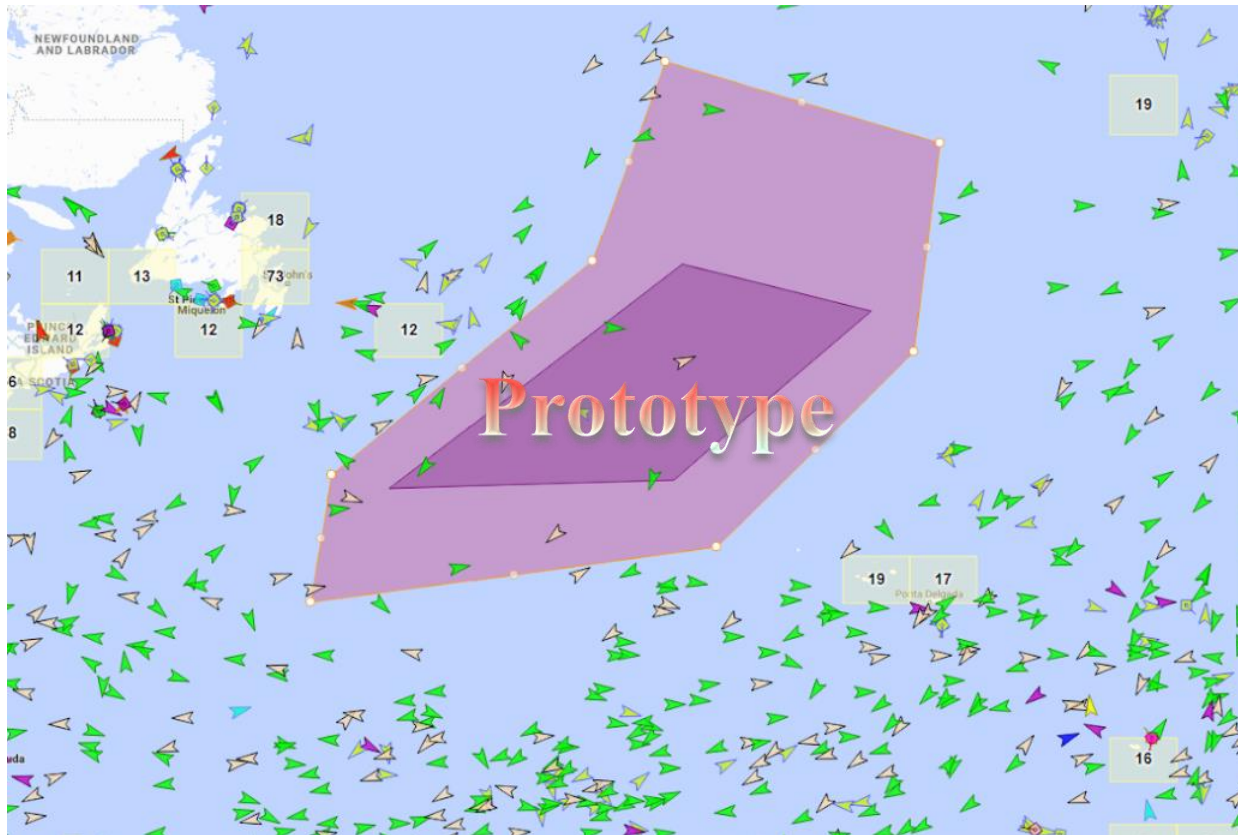




S-412 Weather and Wave Hazards



Hazard Polygons



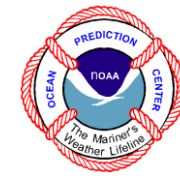
Warnings

191200Z FEB 19
METAREA IV 35/19 (tracking number and year)
WESTERN NORTH ATLANTIC
WARNING
1. HURRICANE FORCE 191200Z TO 201200Z
FEB
WINDS TO 80 KTS, SEAS TO 45 FT
AREA BOUNDED BY
48-06N 036-04W, 46-46N 028-08W
41-40N 036-26W, 41-24N 048-24W
2. CANCEL METAREA IV WARNING 34/19.
3. CANCEL THIS MSG 201200 FEB 19.

191200Z FEB 19
METAREA IV 36/19 (tracking number and year)
WESTERN NORTH ATLANTIC
WARNING
1. STORM 191200Z TO 201200Z FEB
WINDS TO 63 KTS, SEAS TO 36 FT
AREA BOUNDED BY
53-28N 036-48W, 51-24N 025-12W
45-34N 026-18W, 39-32N 034-36W
37-42N 051-42W, 41-50N 050-50W
48-11N 039-50W
2. CANCEL METAREA IV WARNING 33/19.
3. CANCEL THIS MSG 201200 FEB 19.

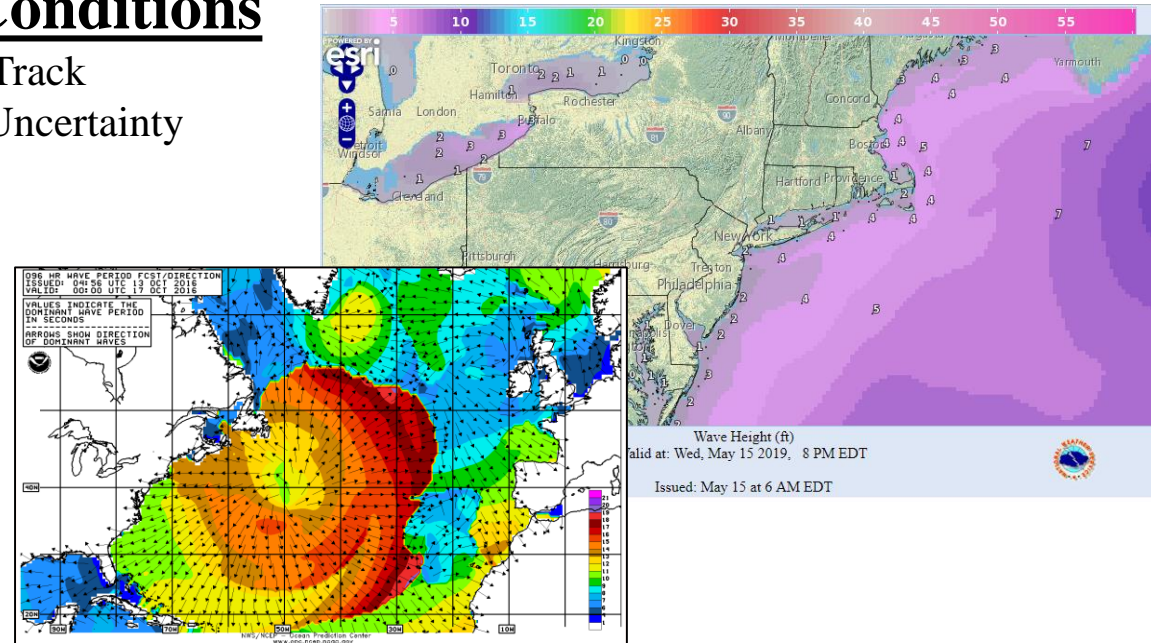


S-413 Weather and Wave Conditions



Weather and Wave Conditions

- Precipitation
- Freezing Spray
- Reduced Visibility
- Wind Gust
- Wind
- Wind Waves
- Primary/Secondary Swells
- Significant Waves
- Atmospheric Pressure
- Temperature
- Minimum/Maximum Temperature
- Cyclone Track
- Cone of Uncertainty



Data Format:

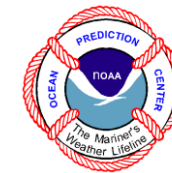
- Hierarchical Data Format 5 (HDF5)
- Geographic Markup Language (GML) 3.2.1

Technical Development Requirements:

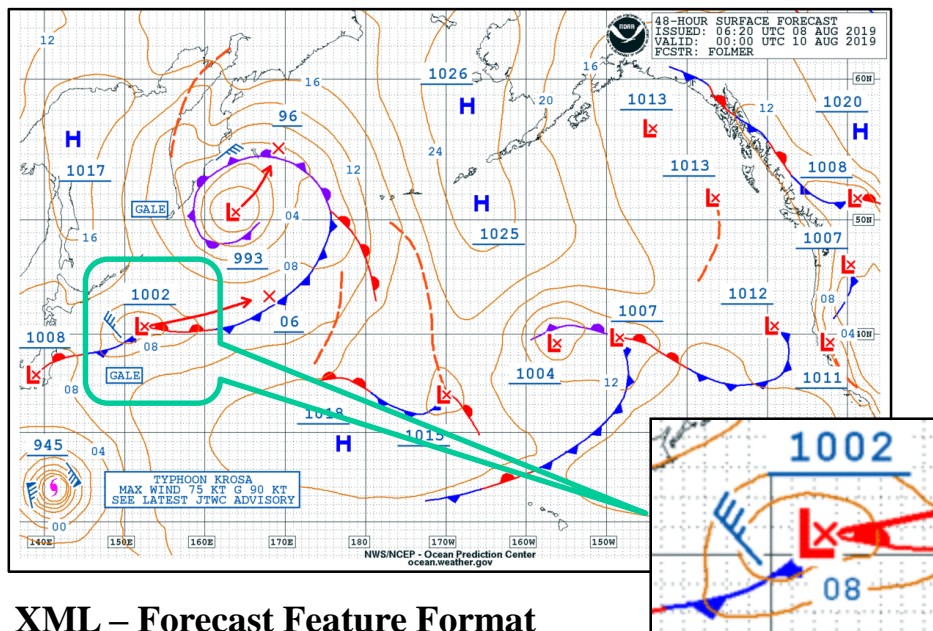
- HDF5 and GML Schema files
- Test and symbol files
- Catalogue files
- Forecast Data → S-100 HDF5 converter
- Forecast Features → S-100 GML converter



XML to GML Conversion



Example: Cold Front from an OPC 48 hour Surface Forecast



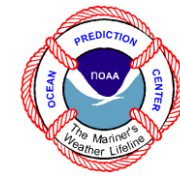
XML – Forecast Feature Format

```
<DrawableElement>
  <Line flipSide="false"
    fillPattern="SOLID" filled="false"
    closed="false" smoothFactor="2"
    sizeScale="1.8" lineWidth="4.0"
    pgenCategory="Front"
    pgenType="COLD_FRONT">
    <Color alpha="255" blue="255" green="0" red="0"/>
    <Point Lon="152.449997" Lat="40.740002"/>
    <Point Lon="149.130005" Lat="38.849998"/>
    <Point Lon="145.110001" Lat="38.119999"/>
  </Line>
</DrawableElement>
```

GML

```
<weather:Front gml:id="FRONT7FR">
  <scaleMaximum>70000000</scaleMaximum>
  <scaleMinimum>1100000</scaleMinimum>
  <validDateTime>20190810T000000</validDateTime>
  <informationProvidedFor></informationProvidedFor>
  <categoryOfFront>1</categoryOfFront>
  <geometry>
    <S100:curveProperty>
      <S100:Curve gml:id="FRONT00007FR">
        <gml:segments>
          <gml:LineStringSegment>
            <gml:posList>
              40.740002 152.449997
              38.849998 149.130005
              38.119999 145.110001
            </gml:posList>
          </gml:LineStringSegment>
        </gml:segments>
      </S100:Curve>
    </S100:curveProperty>
  </geometry>
</weather:Front>
```

Python Conversion and
S-412 Schema Validation



S-414 Weather and Wave Observations

Weather and Wave Observations

- BUOYS
- AIS/Ships Observations
- Satellite Data

Data Format:

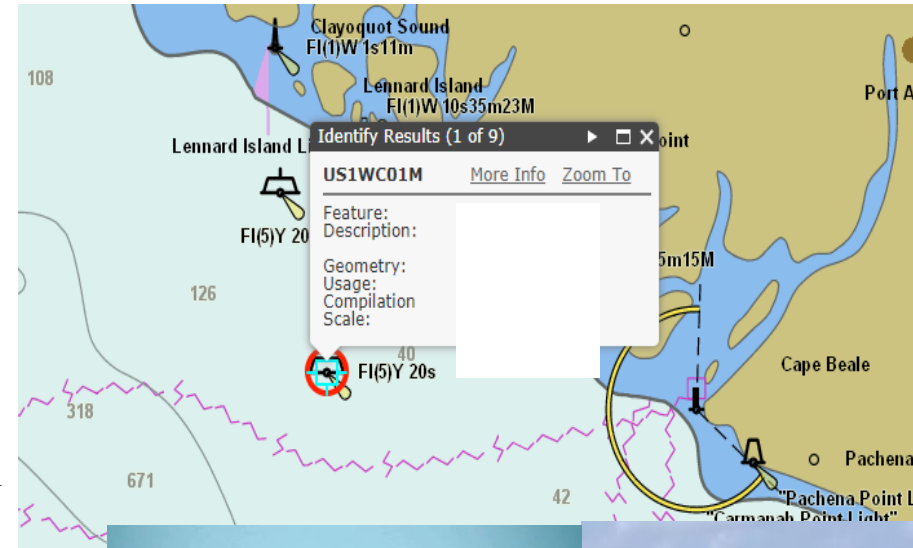
- Geographic Markup Language (GML) 3.2.1

Technical Development Requirements:

- GML Schema file
- Test and symbol files
- Catalogue files
- S-100 GML converter
- Quality control mechanism
- HDF5 or Appropriate

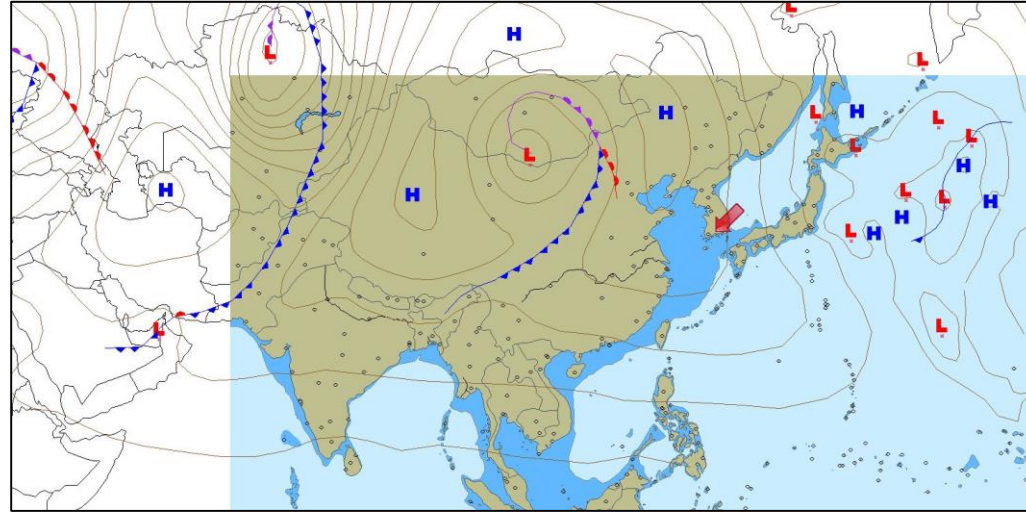
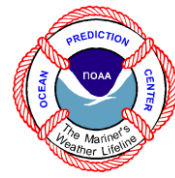
Notes

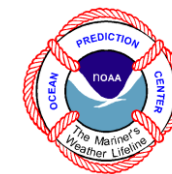
- Interoperability with chart features will be considered.
- Uncertainty in data delivery makes modeling difficult





S-41X Weather Overlay: Testing





S-412 Progress and Required Work

Data Classification
and Encoding
Guide (DCEG)

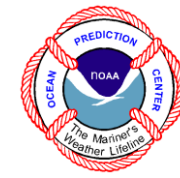
Feature Catalogue

Portrayal
Catalogue



Testing





Vision & Desired Outcome

S-41X Product Specification Schedule

Specification	FY 2018				FY2019				FY2020				FY2021				FY2022			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
S-412		★									★				★					
S-413													★				★			
S-414															★				★	

★ v0.1.0 Released for Comment ★ Planned v0.1.0 Release for Comment ★ Planned v1.0.0 Release

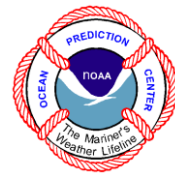
IHO approved separate product specifications

Dependencies:

- JCOMM WWMIWS consensus on content
- Testing relies heavily on IHO Test Bed activities



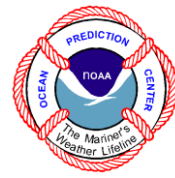
Future Considerations



- Evolution of policy
- Dissemination of products?
- Streamline outputs on a global level
- national meteorology centers technology challenges
 - METAREA providers
 - Collaboration
- Global Weather Layer -> Global Marine Forecasting?



Questions/Feedback

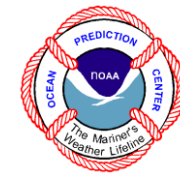


ENS Hillary Fort, Ocean Prediction Center
Hillary.Fort@noaa.gov

Robert Daniels, Oceanographer, Ocean Prediction Center
Robert. Daniels@noaa.gov

Joseph Sienkiewicz, Chief Oceans Applications Branch
Joseph.Sienkiewicz@noaa.gov

Background Slides



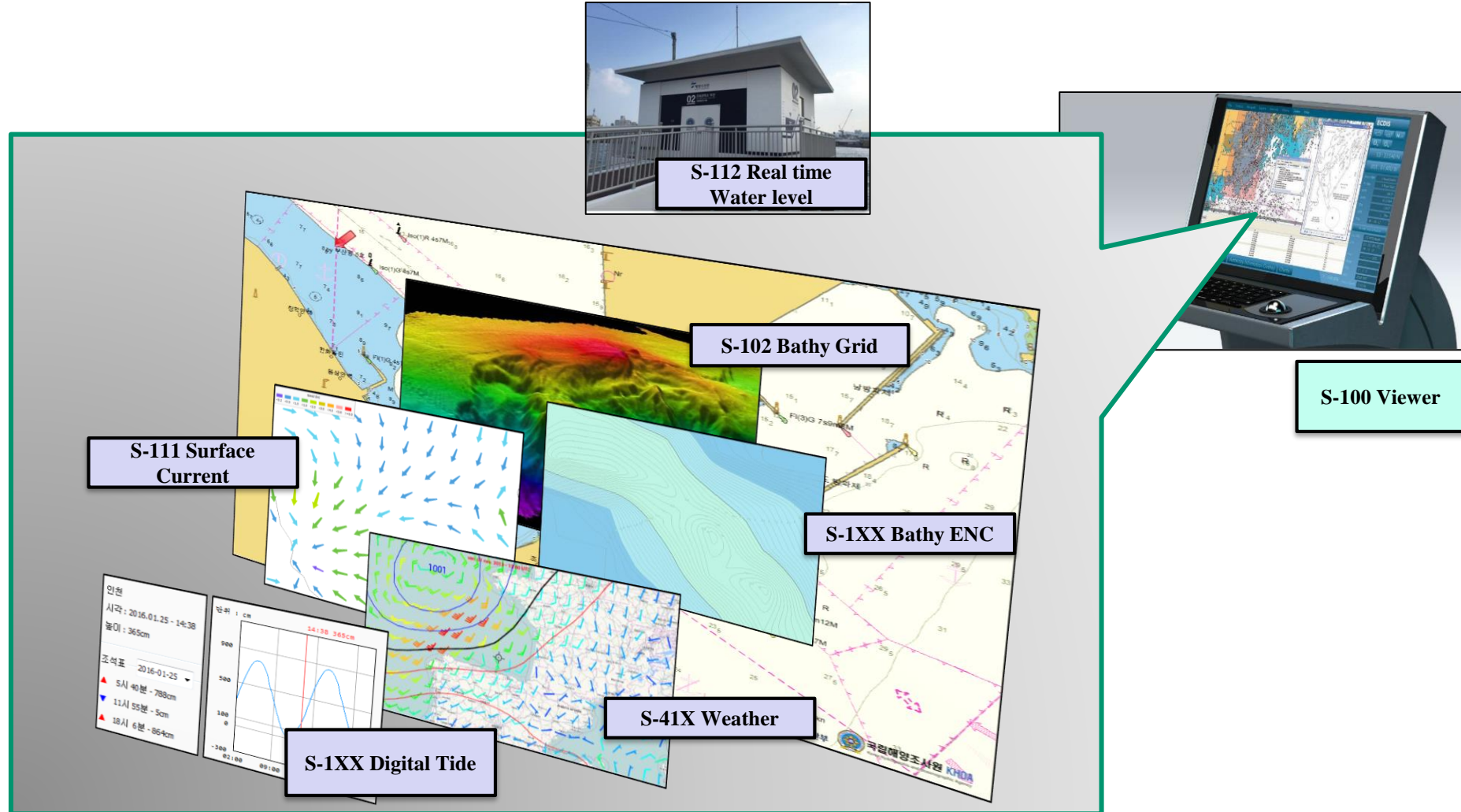
What is S-100?

S-100: Universal Hydrographic Data Model

Provides the **data framework** for the development of the next generation Electronic Navigational Charting products, as well as other digital products required by the hydrographic, maritime and GIS communities

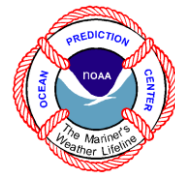


Concept of S-100 Products





S-100 Features



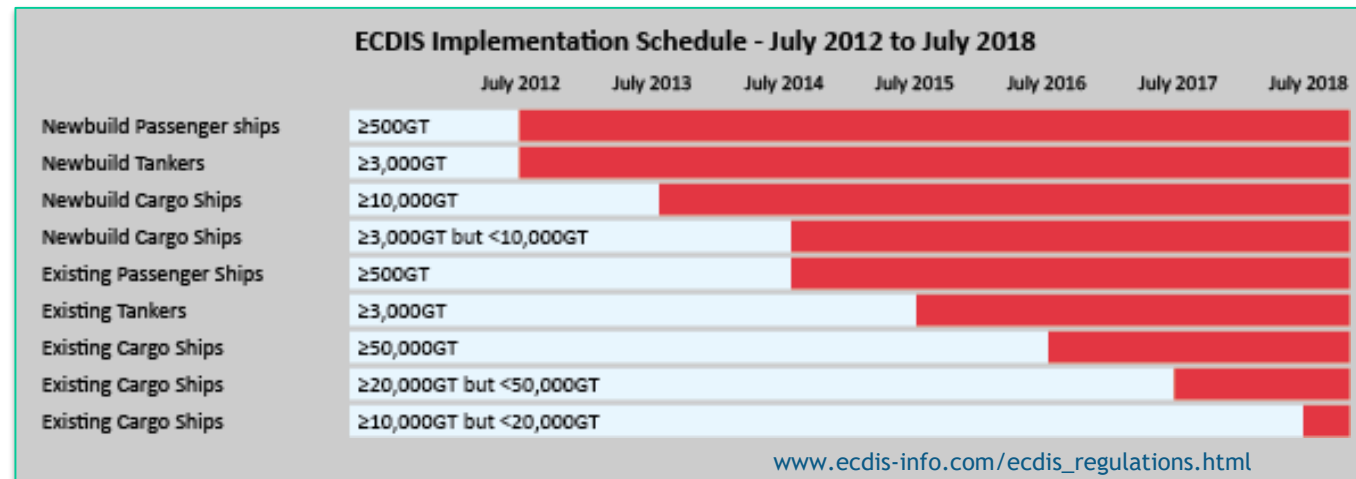
S-100 allows for dynamic content

- Exchangeable and machine readable Feature and Portrayal Catalogues
- Allows for real-time information
- Interoperable with other S-100-based product specifications
 - Electronic Navigation Charts
 - Marine Protected Areas
 - Navigation Warnings
 - High Resolution Bathymetry
 - Tides
 - Nautical Publications
 - Ice Information
- Expanded discovery of metadata



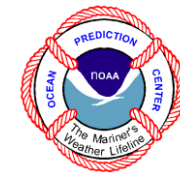
ECDIS and Weather

- ECDIS does not currently include weather products
- Weather products in ECDIS can improve situational awareness, safety, prevention of damaged goods, etc.
- Existing mandatory IMO carriage requirements of ECDIS resulting in widespread adoption





S-41x Weather Overlays: Challenges



- Multiple definitions and impact-based terminology

Global Tropical Cyclone Terminology

Tropical cyclones can be defined in different ways elsewhere in the world. Often news reports from the United States or Asia will refer to hurricanes or typhoons. These are all tropical cyclones, but with different names. While the category definitions are not identical, the following provides an **approximate guide for comparison**

Australian name	Australian category	US*	US Saffir-Simpson category scale*	NW Pacific	Arabian Sea /Bay of Bengal	SW Indian Ocean	South Pacific (East of 160E)
Tropical low	-	Tropical depression	-	Tropical depression	Depression or severe depression	Tropical depression	Tropical depression
Tropical cyclone	1	Tropical storm	-	Tropical storm	Cyclonic storm	Moderate tropical storm	Tropical cyclone (Gale)
Tropical cyclone	2	Tropical storm	-	Severe tropical storm	Severe cyclonic storm	Severe tropical storm	Tropical cyclone (Storm)
Severe tropical cyclone	3	Hurricane	1	Typhoon	Very severe cyclonic storm	Tropical cyclone	Tropical cyclone (Hurricane)
Severe tropical cyclone	4	Hurricane	2 - 3	Typhoon	Very severe cyclonic storm	Intense tropical cyclone	Tropical cyclone (Hurricane)
Severe tropical cyclone	5	Hurricane	4 - 5	Typhoon	Super cyclonic storm	Very intense tropical cyclone	Tropical cyclone (Hurricane)

* Note that the USA uses 1-minute wind averages, which are generally greater than 10-minute wind averages used elsewhere in the world – hence their intensity definitions (wind strengths) will differ by about 10%.

<http://www.bom.gov.au/cyclone/about/intensity.shtml#WindW>

Global Tropical Cyclone Terminology

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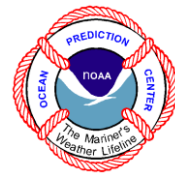
Australian name	Australian category	US*	US Saffir-Simpson category scale*	NW Pacific	Arabian Sea /Bay of Bengal	SW Indian Ocean	South Pacific (East of 160E)
Tropical low	-	Tropical depression	-	Tropical depression	Depression or severe depression	Tropical depression	Tropical depression
Tropical cyclone	1	Tropical storm	-	Tropical storm	Cyclonic storm	Moderate tropical storm	Tropical cyclone (Gale)
Tropical cyclone	2	Tropical storm	-	Severe tropical storm	Severe cyclonic storm	Severe tropical storm	Tropical cyclone (Storm)
Severe tropical cyclone	3	Hurricane	1	Typhoon	Very severe cyclonic storm	Tropical cyclone	Tropical cyclone (Hurricane)
Severe tropical cyclone	4	Hurricane	2 - 3	Typhoon	Very severe cyclonic storm	Intense tropical cyclone	Tropical cyclone (Hurricane)
Severe tropical cyclone	5	Hurricane	4 - 5	Typhoon	Super cyclonic storm	Very intense tropical cyclone	Tropical cyclone (Hurricane)

* Note that the USA uses 1-minute wind averages, which are generally greater than 10-minute wind averages used elsewhere in the world – hence their intensity definitions (wind strengths) will differ by about 10%.

<http://www.bom.gov.au/cyclone/about/intensity.shtml#WindW>



S-41X Weather Overlay



Questions?

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